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Vol. IV MARCH, 1917 No. 3

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

SIXTY-NINTH ANNUAL MEETING.

THE annual meeting of the Boston Society of Civil Engineers will be held at the Boston City Club, Ashburton Place, Boston, on Wednesday, March 21, 1917.

As previously announced, the annual meeting this year will consist of three principal features: a business meeting at noon, the annual dinner in the afternoon and the smoker in the evening.

PROGRAM.

Business Meeting. — The annual meeting required by the constitution will be called to order at 12 o'clock M., in the Assembly Room, on the third floor of the Clubhouse.

Business. — Announcement of the election of new members.

To receive the annual reports of the Board of Government, of the Treasurer and of the Secretary.

To receive the annual reports of the several special committees.

To reappoint the several special committees.

Announcement of the result of letter-ballot for officers for the ensuing year.

Presentation of the Desmond FitzGerald Medal.

Address of the retiring President.

Annual Dinner. — The thirty-fifth annual dinner will be served at half past one o'clock P.M., in the main banquet hall or auditorium on the fourth floor of the Clubhouse.

At three o'clock Mr. Frank M. Williams, state engineer and surveyor of the state of New York, will give a description of the New York Barge Canal and Terminal Connections. Mr. Williams's address will be illustrated with lantern slides and motion pictures.

Smoker. — The usual informal smoker will be held in the evening, in the main banquet hall, beginning at 6.30 o'clock.

S. E. TINKHAM, *Secretary.*

PAPERS IN THIS NUMBER.

"Manchester, Mass., Outfall Sewer." Raymond C. Allen.

"Extension of North Metropolitan Sewerage System Outfall at Deer Island, Boston Harbor." Clarence A. Moore.

Memoirs of deceased members.

CURRENT DISCUSSION.

Paper.	Author.	Published.	Discussion Closes.
"Flood Control in the Miami Valley."	Arthur E. Morgan.	Feb.	April 10.

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Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETINGS.

BOSTON, MASS., February 21, 1917. — A regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, and was called to order at 8.10 o'clock by the President, Richard A. Hale.

There were 125 members and visitors present.

The records of the special meeting of January 10, 1917, and of the regular meeting of January 24, 1917, were approved as printed in the February, 1917, number of the JOURNAL.

The President reported for the Board of Government the election of the following to membership in the Society in the grades named:

Members — Messrs. Charles Gardner Barry, Benjamin Boas, George Robert Burnes, Frank Jay Jerome, William Rhoads Mattson, John E. L. Monaghan, Philip Curtis Nash and George W. Simons, Jr.

Junior — Mr. Edward Hale Clarkson, Jr.

Past President Gow brought before the Society the matter of aiding in the present preparedness movement, and said in part:

" I have recently heard frequent suggestions made by some of our members that a society of the nature of ours, embracing in its membership a collective ability, knowledge and experience which would be of invaluable aid to the community in case of serious emergency, could render very efficient service to the constituted authorities by offering its loyal coöperation in connection with the present preparedness movement now under way in this state.

" As a majority of the members undoubtedly are aware, there has recently been appointed by the Governor of the Commonwealth, a committee of one hundred citizens, known as a Committee on Public Safety, created for the purpose of studying questions involved in adequately protecting the community against the possible hostile acts of a public enemy. This committee has delegated the details of management to an executive committee, which in turn has appointed various sub-committees of citizens to cover particular features of the main problem. Already there have been named some fourteen sub-committees, but as yet no committee on engineering has apparently been contemplated by the executive committee.

" I believe, and I hope you all believe with me, that at this critical moment in our history, when all citizens have an opportunity to demonstrate their loyalty to country and to state, our Society should not be backward in at least volunteering its assistance to those public authorities who may stand in need of such help.

" If the initiative is taken by the Society, I assume that we might be requested to name a representative engineering committee that would be competent to study and report upon any engineering detail, civil, sanitary or structural, which might arise in the consideration of a proper defensive system.

"In order to bring this matter properly before the Society, I move, Mr. President, that the Society tender its services to the Massachusetts Committee on Public Safety for such duties or services as this committee may request of it."

The motion was seconded by Past President FitzGerald and adopted by a unanimous vote.

The Secretary presented the following memoirs of deceased members, which had been prepared by committees of the Society: That of Edward D. Bolton, prepared by Frederick M. Hersey and Daniel W. Pratt, committee; that of Thomas F. Richardson, prepared by Hiram A. Miller, committee; and that of Frank E. Shedd, prepared by Mr. Frank W. Reynolds, of Boston, submitted by Charles T. Main, committee.

By vote, the memoirs were accepted and ordered printed in the JOURNAL of the Society.

The President then called on Past President James W. Rollins, who gave a most interesting account of the work that had already been done on the construction of the Boston Dry Dock. The description was very fully illustrated by lantern slides.

A discussion followed, in which Messrs. Frank W. Hodgdon, Charles R. Gow, Lewis E. Moore, C. Frank Allen, and others took part.

Adjourned.

S. E. TINKHAM, *Secretary.*

BOSTON, MASS., February 7, 1917. — A regular meeting of the Sanitary Section, Boston Society of Civil Engineers, was held this evening in the Society Library, Tremont Temple.

The meeting was opened at 7.30, by the chairman, Frederic Bonnet, Jr.

The chairman appointed the following committee to nominate officers for the coming year: Messrs. Edmund M. Blake, chairman; George A. Sampson and Arthur D. Marble.

On motion of Mr. A. L. Fales, it was voted "to authorize the chairman to appoint a special committee to study, collect data and report upon the distribution of excessive rainfall in Boston and vicinity."

The chairman spoke to the members regarding the coöperation of sanitary engineers with the government in military affairs, and suggested that the Section take some action in the matter. The question was discussed by Professor Whipple and Messrs. King and Wright.

On motion of Mr. George A. King, it was voted that the Executive Committee be empowered to confer with the main Society with regard to taking some action in the matter.

The speaker of the evening, ex-Chairman Stephen DeM. Gage, gave a very interesting talk on "Sewage Disposal in Rhode Island."

It was voted to extend a rising vote of thanks to Mr. Gage, for his interesting talk.

There were 42 present, and the meeting adjourned at 9.20 P.M.

(Signed) JOHN P. WENTWORTH,
Clerk pro tem.

APPLICATIONS FOR MEMBERSHIP.

[March 5, 1917.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

COBURN, STUART E., Norwood, Mass. (Age 26, b. Walpole, Mass.) From September, 1913, to October, 1915, chemist with sewer department, city of Worcester, Mass.; from October, 1915, to date, with Metcalf & Eddy, during which period has been located at Norwood in direct charge of control work and experimental work on wastes from tannery of Winslow Bros. & Smith Co. Refers to Frederic Bonnet, Jr., H. P. Eddy, A. L. Fales and R. S. Lanphear.

COFFIN, GROVER CLEVELAND, Nantucket, Mass. (Age 28, b. Nantucket, Mass.) Graduate of Nantucket High School, 1906; completed prescribed course as apprentice draftsman with General Electric Co., Lynn, Mass., 1909; during winter of 1911–12, student at Boston Y. M. C. A., railroad engineering course; winters of 1912–13 and 1913–14, student at Franklin Union; and in winter of 1915–16 completed first year Lowell Institute buildings course. From June, 1909, to April, 1910, draftsman with General Electric Co.; from April, 1910, to April, 1912, rodman with N. Y., N. H. & H. R. R. Co., construction engineer's department; from April, 1912, to October, 1913, rodman, and from October, 1913, to April, 1914, transitman with Metropolitan Water and Sewerage Board; from April, 1914, to November, 1915, salesman in real estate business; from November, 1915, to May, 1916, computer with Special Tax Committee on Revaluation, City of Cambridge; from May, 1916, to date, resident engineer with Massachusetts Highway Comm.; since January, 1917, temporarily employed as computer for Special Tax Committee, City of Cambridge, while on leave of absence from Massachusetts Highway Comm. Refers to J. J. Casey, J. J. Preble, C. H. Restall, F. D. Smith, and A. S. Tuttle.

HANF, FRANK SIDNEY, Chelsea, Mass. (Age 25, b. Saxonville, Mass.) Graduate of Chelsea High School, 1911, technical course; completed courses in railroad engineering, structural design, etc., at B. Y. M. C. A. Evening School and Franklin Union, during winters of 1911 to 1916, inclusive. From September, 1912, to May, 1913, chainman with real estate department, B. & M. R. R.; during May and June, 1913, draftsman with T. A. Appleton, C. E., Salem, Mass.; from June, 1913, to January, 1914, rodman with Massachusetts Highway Comm.; from January, 1914, to January, 1915, transitman, draftsman and chief-of-party with B. & A. R. R.; from January, 1915, to May, 1916, title researchman with valuation department, B. & M. R. R.; from May, 1916, to date, resident engineer on highway construction with Massachusetts Highway Comm.; since December, 1916, while on leave of absence from Massachusetts Highway Comm., temporarily employed as draftsman with valuation department, N. Y., N. H. & H. R. R. Refers to

Allen Curtis, R. W. Coburn, G. M. Harris, T. P. Perkins, F. B. Rowell and J. B. Russell.

Murphy, John W., Springfield, Mass. (Age 25, b. Beverly, Mass.) Graduate of Massachusetts Agricultural College, 1916, course in landscape architecture and civil engineering. From March, 1916, to date, with C. R. Parker, landscape architect, as superintendent of all construction of engineering nature, including sewerage, water supply, reinforced concrete work, road building, etc. Refers to A. B. Appleton, G. P. Connolly, S. J. Connolly, J. W. Raymond, Jr., and H. L. Whitney.

O'Neil, Joseph Leon, Somerville, Mass. (Age 27, b. Cambridge, Mass.) Educated in public schools, including Concord, Mass., High School. Has been engaged in engineering work since 1907; employed on railway, sewer and city work by A. W. Sherry, New Haven, Conn.; on double-tracking of Boston & Worcester Railway by E. H. Rogers, chief engineer; on landscape work by E. W. Bowditch; and on valuation work by N. Y., N. H. & H. R. R. and B. & M. R. R. companies; is now draftsman with B. & M. R. R. Co. Refers to W. G. Burleigh, J. H. Duffy, S. J. Gulesian, G. M. Harris, Malcolm Rich, J. B. Russell and F. C. Shepherd.

LIST OF MEMBERS.

ADDITIONS.

Babcock, John B.............Mass. Inst. of Technology, Cambridge, Mass.
Clarkson, Edward H., Jr...............44 Langdon St., Cambridge, Mass.
Strout, Henry E., Jr.....................11 Westerly St., Roxbury, Mass.
Tomasello, Joseph A....................73 Gibson St., Dorchester, Mass.

CHANGES OF ADDRESS.

De La Haye, Elias F., Jr...................50 Perrin St., Roxbury, Mass.
Desmond, Edwin A......................90 Florida St., Dorchester, Mass.
Drummond, William W...Office of Quartermaster, Fort H. G. Wright, N. Y.
Eisnor, John J..........................28 Bowdoin St., Medford, Mass.
Elkins, Clayton R.....................36 South Perry St., Dayton, Ohio
Emerson, Ralph W.................Kinnell-Kresge Bldg., Pittsfield, Mass.
Fernald, Gordon H.,
Care Milo H. Fernald, 908 8th St., San Bernardino, Cal.
Flett, Louis E.........Care of Naugatuck Chemical Co., Naugatuck, Conn.
Harris, Gilbert M....................56 Charlesgate East, Boston, Mass.
Hathaway, Erwin O....................512 St. Peter St., St. Paul, Minn.
Kendall, Theodore R.,
Care of *American City*, 87 Nassau St., New York, N. Y.
Kimball, Herbert S........................75 State St., Boston, Mass.
McSweeney, Thomas F.,
Technology Chambers, Irvington St., Boston, Mass.

Reed, Leslie P. . . . . Care of J. W. Bishop Co., Bridgewater, Mass.
Rew, Morse W. . . . . Care of Transit Commission, Pittsburgh, Pa.
Robinson, John R. . . . . Y. M. C. A., Newton, Mass.
Rourke, Louis K.,
Care of Chile Exploration Co., 120 Broadway, New York, N. Y.

DEATH.

Parker, Alfred W. . . . . February 24, 1917

EMPLOYMENT BUREAU.

The Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society room two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

Men Available.

No. 394. Age 38. Received technical education at University of Pennsylvania, civil engineering course. Has had eight years' experience in railroad engineering, including preliminary and location surveys, maintenance and heavy construction; also four years' experience in general engineering and contracting. Would prefer position as maintenance engineer or superintendent of construction at large plant, but any position in line with above experience would be acceptable, provided location is permanent. Salary desired, $150 to $175 per month.

No. 395. Age 26. Graduate of Tufts College Engineering School, 1914, degree of B.S. Experience includes one year as draftsman, two years as rodman and instrumentman for transit commission, and seven months as instrumentman and inspector of road construction for highway commission. Desires position along civil engineering lines.

No. 396. Age 28. High school graduate; received technical education from I. C. S. course in civil engineering. Has had one and one-half years' experience as rodman and chainman. Desires position as rodman. Salary desired, $75 per month.

No. 397. Age 26. Graduate of Mass. Inst. of Technology, civil engineering course. Experience includes reinforced concrete detailing and design, also municipal work as assistant engineer and superintendent in charge of street division.

LIBRARY NOTES.

Recent Additions to the Library.

U. S. Government Reports.

Accuracy of Stream-flow Data. (Water-Supply Paper 400-D). N. C. Grover and J. C. Hoyt.

Annual Report of Director of United States Geological Survey for 1915–16.

Borax in 1915. Charles G. Yale.

Clay-working Industries and Building Operations in Larger Cities in 1915. Jefferson Middleton.

Coal in 1915. Part A, Production; Part B, Distribution and Consumption. C. E. Lesher.

Coke in 1915. C. E. Lesher.

Copper in 1915. B. S. Butler.

Forest Fires in United States in 1915. J. Girvin Peters.

Gems and Precious Stones in 1915. Waldemar T. Schaller.

Gold, Silver, Copper, Lead and Zinc in Arizona in 1915. V. C. Heikes.

Gold, Silver, Copper, Lead and Zinc in Colorado in 1915. Charles W. Henderson.

Gold, Silver, Copper, Lead and Zinc in Idaho and Washington in 1915. C. N. Gerry.

Magnesite in 1915. Charles G. Yale.

Magnesium in 1915. Frank L. Hess.

Metals and Ores in 1914 and 1915. J. P. Dunlop.

Natural Gas in 1915. John D. Northrop.

Oil Shale in Northwestern Colorado and Adjacent Areas. Dean E. Winchester.

Peat in 1915. James S. Turp.

Petroleum in 1915. John D. Northrop.

Poles Purchased, 1915. Arthur M. McCreight.

Stone in 1915. G. F. Loughlin.

Some Public and Economic Aspects of the Lumber Industry. William B. Greeley.

True Mahogany. C. D. Mell.

Water-Supply Papers 361, 380.

Western Yellow Pine in Oregon.

Width of Wagon Tires Recommended for Loads of Varying Magnitudes on Earth and Gravel Roads. E. B. McCormick.

State Reports.

Maine. Report of State Board of Health for 1914 and 1915.

Massachusetts. Report of Special Commission Appointed to Consider Financial Condition of Boston Elevated Railway Company, 1917. Gift of G. F. Swain.

Municipal Reports.

Binghamton, N. Y. Annual Report of Water Commissioners for 1915.

Chicago, Ill. Unification of Local Governments in Chicago, 1917.

Danbury, Conn. Annual Reports for 1915.

Everett, Mass. Report of Property Assessment Commission, 1916.

Hartford, Conn. Annual Report of Water Commissioners for 1915–16.

New York, N. Y. Annual Report of Department of Water Supply, Gas, and Electricity for 1915; Report of Delos F. Wilcox, Deputy Commissioner, to Department of Water Supply, Gas, and Electricity in Relation to Citizens Water Supply Company of Newtown, 1916.

Miscellaneous.

Canada, Department of Mines: Summary Report of Mines Branch for 1915.

Colorado Agricultural College Experiment Station: Comparative Bacteriological Study of Water Supply of City and County of Denver, Colorado. Walter G. Sackett.

National Board of Fire Underwriters: Reports and bulletins on the following cities: Altoona, Pa.; Augusta, Ga.; Boston, Mass.; Brockton, Mass.; Buffalo, N. Y.; Cambridge, Mass.; Cleveland, O.; Fall River, Mass.; Fitchburg, Mass.; Gloucester, Mass.; Hartford, Conn.; Haverhill, Mass.; Holyoke, Mass.; Lawrence, Mass.; Malden, Mass.; Manchester, N. H.; Muskogee, Okla.; New Bedford, Mass.; New Britain, Conn.; New Orleans, La.; North Tonawanda, N. Y.; Oklahoma City, Okla.; Passaic, N. J.; Pittsfield, Mass.; St. John, N. B.; Salem, Mass.; Somerville, Mass.; Shreveport, La.; Taunton, Mass.; Tonawanda, N. Y.; Waltham, Mass.; Tulsa, Okla.; Washington, D. C.; White Plains, N. Y.

Duplicates for free distribution to members will be found this month, as usual, on the ends of the reading-room tables.

Attention is called to the fact that all duplicates offered to members are plainly marked as such, and that a list of them is placed on the top of the pile. It has been found that publications not duplicates, when left on the tables by readers, sometimes stray into the pile and are mistaken for duplicates. Members are therefore requested not to take for their own files any publication that does not appear on the list referred to above, without first consulting the Assistant Librarian.

The list for this month is as follows:

Baltimore, Md.: Report of Sewerage Commission, 1897.

Boston, Mass.: Annual Reports of City Engineer for 1876 and 1881; Annual Reports of Park Commissioners for 1876, 1877 (2 copies), 1879–82; Second Report of Park Commissioners, 1876; Fourth Report of Park Commissioners, 1876 (3 copies); Sixth Report of Park Commissioners, 1877 (2 copies); Parks for the People — Proceedings of Public Meeting at Faneuil Hall, 1876; Map of Back Bay Park, 1877; Proposed West Roxbury Park, 1879; Proposed Arboretum at West Roxbury, 1880; Notes on Plan of Franklin Park, 1880 (2 copies); Report on Present System of Sewerage, 1873; Sewerage of Boston, 1876 (3 copies); Report of Joint Special Committee on Improved Sewerage, 1877; Annual Report of Mystic Water Board for 1875; Annual Report of Boston Water Board for 1881; Annual Report of Water-Supply Department for 1893 (3 copies); Annual Report of Water Department for 1895; Report on Introducing Pure Water into City of Boston, 1834; Report on Plan for Supplying City of Boston with Pure Water, 1837; Report on Material for Distribution Water Pipes, 1848: Report of Joint Standing Committee on Additional Water Supply, 1874; Report of Cochituate Water Board on Mystic Water, 1874; Report of Medical Commission on Sanitary Qualities of Sudbury, Mystic, Shawshine, and Charles River Waters; Report of Commissioners on Investigation of Water Supply, 1883; Report of Commission on Annexation of Certain Neighboring Cities and Towns, 1873; Report on Nomenclature of Streets, 1879; Digest of Statutes relating to Inspection and Construction of Buildings, 1886.

Gloucester, Mass.: First Annual Report of Water Commissioners, 1896.

Holyoke, Mass.: Annual Reports of Water Board for 1895, 1897–1899, 1902; Hearings in Case of Holyoke Water Power Company *v.* City of Holyoke, Vol. XVI (2 copies).

Industrial Arts Index, February–October, 1916.

Leicester, Mass.: Annual Reports of Water Commissioners for 1888–1891.

Lowell, Mass.: Annual Reports of Water Commissioners for 1872 and of Water Board for 1874, 1888–1910; Report of Joint Special Committee on Supply of Water, 1869.

Lynn, Mass.: Annual Reports of Water Board for 1872–1873, 1897–1898, 1900–1906, 1909–1910.

Massachusetts, Highway Commission: Annual Reports for 1896, 1898, 1899.

Massachusetts, Topographical Survey Commissioners: Annual Reports for 1897–1900.

New York, N. Y.: Aqueduct Commission Reports on New Croton Aqueduct, 1883–1887.

Newton, Mass.: Annual Reports of City Engineer for 1892, 1893, 1899, 1900, 1904–1908; Hearing on Method of Sewer Assessments, 1891 (3 copies); Annual Report of Water Board for 1886.

Pawtucket, R. I.: Quarterly Reports of Water Commissioners for June–December, 1877.

Portland, Me.: Report of Committee on Water District, 1903.

Somerville, Mass.: Annual Reports of City Engineer for 1903, 1905, 1907; Annual Reports of Mystic Water Board for 1886, 1888–1894, 1897, and of Water Commissioners for 1898, 1901, 1905, 1906.

Taunton, Mass.: Annual Report of Water Board for 1911.

Wellesley, Mass.: First Report of Water Department, 1885; Annual Reports of Water Department for 1897, 1899, 1901, and of Water and Municipal Light Board for 1903, 1904.

Wilmington, Del.: Annual Reports of Water Commissioners for 1904, 1906, 1907, (1907–08)–(1909–10), 1911–12, 1912–13.

Worcester, Mass.: Annual Reports of Water Department and City Engineer for 1878, 1881–1882, 1887, 1889–1899, 1901, 1908; Report of Committee on Additional Supply of Water, 1877; Annual Reports of Superintendent of Sewers for 1902, 1903; Worcester Sewage and Blackstone River, 1882.

LIBRARY COMMITTEE.

NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before the 1st of each month.)

Commonwealth of Massachusetts. — METROPOLITAN PARK COMMISSION. — *Old Colony Parkway.* — Bids will be received February 26, 1917, for construction of Neponset Bridge.

BOSTON TRANSIT COMMISSION. –– *Dorchester Tunnel* has been practically completed from its beginning at Tremont St. to a point under Dorchester Ave. near Broadway in South Boston.

Work is progressing on the Broadway Station, which extends in Dorchester Ave. from Broadway to West Fourth St. The T. A. Gillespie Co. is the contractor.

Work on Section G, which extends in Dorchester Ave. from West Fourth St. to Old Colony Ave., is substantially completed north of the N. Y., N. H. & H. R. R. Co. cut, except the resurfacing of the street. Work at and south of the railroad cut is now in progress. Coleman Brothers are the contractors.

Section H and Section H Extension, which are completed, extend in Dorchester Ave. from Old Colony Ave. to near Dexter St.

The next section, Section J, extending from a point near Dexter St. in a southerly direction in and near Dorchester Ave. and Boston St. to a little south of Ralston St., and embracing the station in Andrew Sq., is being constructed. The work is about three fourths done, the work remaining being in Boston St. and in the station south of Dexter St. The T. A. Gillespie Co. is the contractor.

City of Boston. — PUBLIC WORKS DEPARTMENT. — HIGHWAY DIVISION, PAVING SERVICE.

Caledonian Ave.,	Spring St., southerly.	Grading.
Hubert St.,	Shawmut Ave. to Westminster St.	Grading.
Ralston St.,	Dorchester Ave. to Old Colony Ave.	Grading.

PUBLIC WORKS DEPARTMENT, BRIDGE AND FERRY DIVISION. — *Strandway Improvement.* — The New York State Dredging Corporation has started work on the Strandway Improvement, South Boston.

This work involves the extension of the concrete sewer outlets at H, Vale, and Kemp streets and Crescent Ave.; the construction of a wooden bulkhead 1 700 ft. long, extending easterly from a point near Columbia Road Bridge into Old Harbor; reclamation of some seventy-five acres of flat land on the shores adjacent to Old Harbor by hydraulic fill; the construction of a fifty-six acre playground, surrounded by suitable drives and walks; and the construction of a new concrete bathhouse near McKenzie Beach capable of bathing four thousand people per day.

In spite of very unfavorable weather and ice conditions, all the sewer work has been started, and the bulkhead about seventy-five per cent. completed.

New York, New Haven & Hartford R. R. Co. — *Boston Mass., Southampton Street Engine Facilities.* — Work consists of new 39-stall engine house, 95 ft. turntable, ash pits, boiler house, office building, water tank and necessary trackage.

During past month, completed excavating for engine house, office building and ash pits; completed driving concrete piles for engine house and office building and progressing on driving of concrete piles for ash pits and pouring of concrete foundation for engine house.

Fore River Shipbuilding Corporation, Quincy, Mass., has the following work in progress:

Eight torpedo boat destroyers for the United States Government.

Twenty-seven submarines for the United States Government.

Two oil tankers for the Texas Company.

Two oil tankers for the Mexican Petroleum Company.

One oil tanker for the Argentine Government.

Three freight steamers for the Luckenbach Company, Inc.

Two general cargo vessels for the Cunard Steamship Company.

Vol. IV MARCH, 1917 No. 3

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

MANCHESTER, MASS., OUTFALL SEWER.

By RAYMOND C. ALLEN, MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.*

(Presented before the Sanitary Section, January 3, 1917.)

THE town of Manchester is a small coast town on Cape Ann, Massachusetts, lying between Beverly and Gloucester, having an area of about 8 square miles and a population of about 2 900. Settled about 1629, its growth was for many years slow, and except for a period of about forty years in the middle of the last century, when as a center of cabinet manufacturing it attained national reputation in that line, its history and growth was similiar to that of hundreds of other small communities. Between 1870 and 1880, however, the development of this small town as a summer resort began making possible and necessary many public improvements which otherwise probably would have been foregone. Beginning with Richard H. Dana, the author, followed by Boston families and later by people from the whole country, Manchester, together with other parts of the North Shore of Massachusetts, has become a summer playground of wealthy families.

The original village was largely grouped along the valley of Sawmill Brook, the only considerable stream in the town,

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NOTE. Discussion of this paper is invited, to be received by W. L. Butcher, editor, 14 Beacon Street, Boston, before May 10, 1917, for publication in a subsequent number of the JOURNAL.

* Civil Engineer, Manchester, Mass.

while the estates of the summer residents followed, first, the coast line, and later the hills around the village, overlooking the sea.

In 1892, the town, almost at the point of accepting the proposition of a private water company, after most lively debate and with many misgivings, installed a water system, which was enlarged in 1908. The growth of the town took a new start with this improvement, and with the increasing number of summer estates the population of the village was augmented by the families of servants and mechanics seeking the employment thus provided.

With the introduction of water came, as a natural result, the installation of water-closets to replace the old-fashioned privies of the village. Estates along the shore disposed of their sewage by emptying it into the ocean, while those on the hills about the town in many cases installed filter beds of more or less effectiveness. In the village, however, wherever possible, the drainage of houses flowed directly or indirectly into the main brook and its tributaries, or into old storm drains which eventually discharged into the main brook and the inner harbor of the town. This created a condition which gradually became offensive and at last started an agitation, weak at first, but gradually gaining strength, which sought primarily to better the condition of the village and its stream and harbor. The outcome was a study and report upon a sewerage system for the town, undertaken by Mr. Desmond FitzGerald, who made a thorough and careful report to the town in 1912.

Mr. FitzGerald was very loath to recommend the discharge of sewage into the harbor even at its mouth, and spent a great deal of time and study seeking suitable places for filter beds and similar methods of disposal. Unfavorable conditions of soil, the large extent of the watershed of the water system in the town, and the high value of available land, together with the large resulting damage to adjoining holdings, should such a method of disposal be adopted, led him finally to recommend that the sewage of the town, collected by a separate system of sewers and pumped from a collecting basin at the harbor front, be treated in an Imhoff tank on one of the islands of the outer harbor, and thence discharged by gravity into the ocean in deep water.

This report was considered by a committee of the town, and the general plan studied by the State Board of Health. The construction of the outfall necessary to reach House Island, the only suitable island, — about one-half mile from shore, — was upon careful investigation found to be in all probability very expensive, and it was finally decided, in view of the comparatively small amount of sewage, to seek a direct outlet into deep water at some point in the outer harbor where no ledge would be encountered in the trench for the pipe and where the construction might proceed with the least difficulty in stormy or rough weather. This proposition was approved by the State Board of Health, and the town voted to proceed with the work and authorized a bond issue of $225 000 therefor.

The system recommended by Mr. FitzGerald and carried out by the town, with the exception of the Imhoff tank at the outfall, consists of a separate system of sewers throughout the village, about eight miles in length, and ranging from 6-in. vitrified pipe to 30-in. cast-iron pipe. Much of the system is below high water, and all such consists of cast-iron pipe. The sewage is collected at a point near the center of the village, on the harbor front, in basins consisting of duplicate tanks of about 60 000 gals. capacity each. From these collecting basins the sewage is pumped, by electrically driven pumps, to a point of discharge in the outer harbor in forty feet of water at low tide.

There is little of interest in the street system of the town, the only unusual features being a great amount of ledge and much water. Owing to liberal use of iron pipe, however, leakage has been kept down to a reasonable amount, although, were the work to be done over, the writer would increase the length of the iron pipe to cover certain portions of the system where the level of the ground water is quite high.

The collecting basins and pumping station offer a few features of interest, and before describing the outfall sewer the write will briefly describe them. The site of this plant was on the shore of the inner harbor, on marsh land the surface of which is at about elevation 9.5 ft. above low water. Sewage was to enter at about elevation −1.00 ft. and discharge through about 8 700 ft. of 14-in. cast-iron pipe into the sea, at a depth of 40 ft. at low water.

The design of this plant was made by Metcalf & Eddy, of Boston, in collaboration with Mr. FitzGerald, and the work was constructed under the supervision of the writer. As designed, the floor of the tanks is at an elevation of 12.17 ft. below low water, and the floor of the pump well at an elevation of 15.08 ft. below the same datum.

In the original report, covering this feature of the construction, $35 000 was allowed for the work, including station equipment. Prior to asking for bids upon the work, two test wells or wash borings were made at the site of the work, and it appeared that the structure would be entirely in clay, the upper portions apparently in hard blue clay, the lower in softer yellow clay, and that, further, at some eight feet below the subgrade of the bottom of the tanks, occurred a deep stratum of water-bearing sand.

These findings discouraged bidders, and but two bids were secured, one being $28 177 and the other $33 093. Both were rejected, and the Charles R. Gow Company was employed to excavate a shaft three feet in diameter to a little below the proposed bottom of the tanks, all contractors being given an opportunity to see the actual conditions as the excavation progressed. This work cost $300, and was well done. The results showed that the work would lie in stable blue clay, and new bids were called for.

As a result, the new bids ranged from $15 300 to $33 000, and the contract was awarded to the Charles R. Gow Company, who with little difficulty carried the work to a speedy and successful conclusion.

The sewage enters the tanks through a screen chamber, in which are controlling gates allowing either tank to be used. At one side of the tanks and the screen chamber is located the dry pump well. Here are installed two 6-in., 1 000-gals. per minute, Lawrence vertical centrifugal pumps, driven by 25 h.p. General Electric motors, direct connected and running at 2 300 volts and at 1 800 r.p.m. The pumps, below the level of the bottom of the tanks, are always primed and are so arranged that either tank can be operated by either pump. The sewage is discharged through a Venturi meter, although as yet the recording apparatus has not been installed. Consequently, in order to secure a record of the flow, two Bristol self-recording gages have been installed.

The operation of the station through nearly two years has shown it to have been well designed, no objectionable odors having been encountered and the purposes for which it was planned having been well met. One feature only gave trouble. This was for a time annoying and consisted in our inability to keep the shafts in line. These, 30 ft. in length and running at 1 800 r.p.m., were planned with what proved to be insufficient steady bearings, although, if run as at first contemplated, 900 r.p.m. or thereabouts, the writer does not think any trouble would have resulted. The addition of a complete new system of bearings and braces obviated this difficulty.

As finally determined, it was planned to construct the outfall sewer, from the pumping station above described, to a point in the outer harbor where deep water would be found and a route free from ledge obtained. The location of this outlet was to be determined at such a point that the currents should if possible under practically all conditions be such that no sewage should return to the shores.

As a preliminary to the investigation for these purposes, a careful survey was made of the entire harbor, triangulation stations established and all prominent features on shore located.

Floats of the usual types for surface and submerged work were prepared and set out at various points, and their tracks followed and plotted until all reasonable conditions of wind and tide had been investigated. In following these floats, a motor boat with an attendant to operate it was employed. In the boat, the man in charge of the survey work, with a recorder, followed the floats and at regular intervals located them by measuring angles to any prominent buildings, stations or other features on shore or to government buoys visible, all of which had been plotted previously. Angles were taken by a small quadrant, sometimes called a "dredging" quadrant, of the type used by the Harbor and Land Commission, which for this purpose was found to be excellent. Numerous tests of its accuracy were made by locating the same points from two transit stations, the results invariably plotting within a very few feet of each other. After the results of these experiments had been studied, it was found that an outlet might safely be placed anywhere west of House Island and within about two thousand feet of it, and that, in such a location, little trouble need by anticipated from sewage returning to shore.

It now became necessary to take soundings to determine where to lay the line. It was planned to lay the pipe in a trench at the bottom of the harbor, so that it should be covered at least four feet, and naturally ledge was not desired. Soundings were therefore taken over a considerable area, which included all possible routes. By using grease upon the bottom of the lead, the nature of the bottom was quite readily determined, and by keeping tide-gage readings at fifteen-minute intervals, the depths below low water were closely obtained. After the results of these soundings had been plotted, the contour and extent of the ledgy bottom were drawn with considerable accuracy, and the fact appeared clear that the rocky islands of the harbor extended below water to a wide distance about them.

Upon this plan, routes were selected for an outfall, and borings arranged for. How to make these borings accurately and economically was a question which gave considerable concern. The writer was unable to find any literature on the subject or to get any very definite advice. What he wished to do was to obtain soundings to a depth of six feet below the bottom of the harbor and bay, to make sure that there was no ledge and to determine as far as possible the nature of the material. At first a lighter and tug boat were chartered, it being planned to sound from the lighter with one-inch pipe having a chisel end, guided and held in place by passing it through 3-in. pipe strapped to the side of the lighter. This outfit started in about fifty feet of water at low tide, at a point selected for the outlet, and worked toward shore. The arrangement outlined did not work very well, and, after we had carried away several lengths of pipe, was abandoned and soundings made with heavier pipe from a platform on the side of the lighter. With this arrangement, some 2 000 ft. of borings were taken at about 50-ft. intervals, located from shore from two triangulation stations. The time of all borings was taken, and tide-gage readings carried on simultaneously. The results were slow, expensive and not as uniform as desired. The lighter was unwieldy, and in any sort of a ground swell accurate results could not be obtained.

We next chartered a large gasoline-driven launch. A hole was cut in her bottom, and a well constructed. Through this well, soundings were taken with a line of pipe as before, and very good results obtained with greater economy and accuracy than before. The deep water work was completed with this outfit. When a depth of not over ten feet of water at low tide was reached, soundings were taken at low tide directly from a rowboat, and the work completed. If the writer were to do this work again, he would be inclined to employ a small scow or lighter, erect a small tripod on it and sound from this, towing with a gasoline launch and working along with four anchors. He is very sure that he would be able to get just as accurate results and do it more quickly and cheaply.

With the borings obtained, covering the routes projected at about 50-ft. intervals, a route was selected which showed no ledge in the soundings nor on the bottom.

The soundings covered only the outer harbor, as no difficulty was anticipated in the inner harbor, which had been repeatedly dredged and found to be mud and clay. To reach the outer harbor from the inner harbor, it was at first planned to cross the inner harbor to the shore of the westerly side and run as far on land as possible before departing for the outlet. This we thought would be the cheaper although longer operation. Consultation with some who had had experience in these matters led us to ask for bids on alternate routes, all under water and nearly all below low tide.

Specifications were prepared calling for bids on this work, the town supplying the iron pipe at the town wharf in the village. There were two main provisions in the specifications; first, that the pipe should be laid with a cover of at least four feet in the bottom of the harbor; and, second, that it should, on completion and before acceptance, successfully withstand a test of an internal pressure of 50 lbs. per sq. in. without perceptible leakage.

Bids were received as follows, the all-water route being called Route A; and the part land and part water, Route B.

	A.	B.
T. A. Scott Company	$56 800	$60 000
Wm. Gerrish	59 100	.....
W. B. Bryne	57 000	65 000
C. R. Gow Company	65 000	68 000
Merritt and Chapman	61 873	74 322

The bid of T. A. Scott Company for Route A was accepted, work commenced in June, 1914, and completed in January of 1915.

The first steps were the dredging of the trench for the entire route and the drilling of some ledges in a short section which was bare at low water. The outfall end was located from shore by two transits; and a float anchored to mark the point from which the dredger should work toward ranges on land but so far away that close watch from the survey stations was needed to keep the line straight. Further inshore, the work was easily controlled by ranges on shore and on the flats.

While the dredging was in progress, work was being carried on in constructing the outfall end in one mass, ready to lower in place at the proper time. It had been expected that it would be necessary to build a pile structure at the outfall end to which to tie the pipe, but after the dredging had been completed it was found to be ledge at a depth of about six feet below the bottom. A platform, 16 ft. square, was now constructed of 6 in. by 6 in. tongued and grooved stock, laid in two layers, at right angles to each other and solidly bolted together. Upon this platform was made up one length of 14-in. pipe and 3 $\frac{1}{16}$ bends upturned, the whole solidly secured to the platform. Around this was now cast a hemisphere of concrete having a diameter of about 8 ft. and weighing about 20 tons. (Fig. 1.) When completed, this was taken to the outlet and lowered in place, being leveled on the bottom by the divers and protected and brought to proper line and grade by building up with concrete in bags. At this time, also, the upturned end was plugged with a 6-in. tapered plug of pine wood into which had been tightly fastened a 2-in. pipe and valve for future use in testing.

From the pipe thus laid, the line was laid toward shore, and meanwhile the dredgers moved in shore to dig other portions of the line.

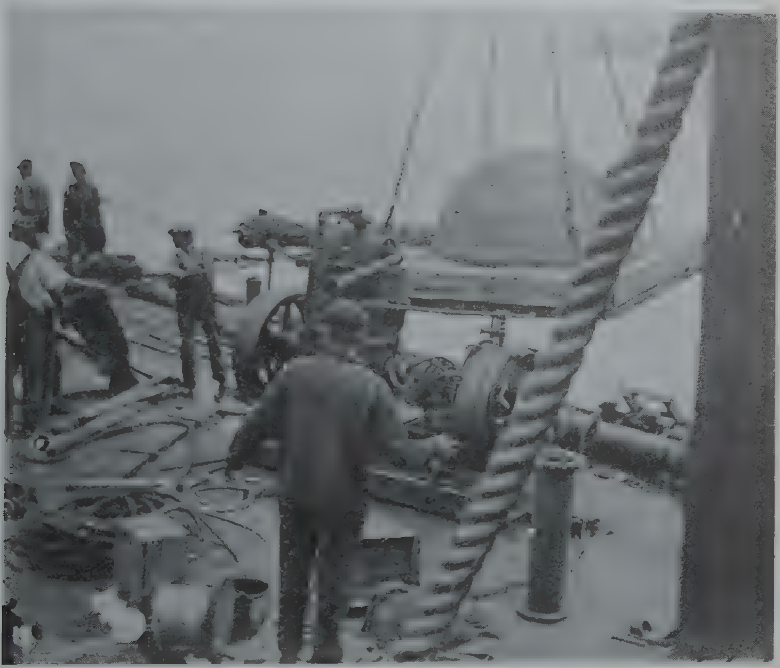

FIG. 1. OUTLET STRUCTURE SHOWING CONCRETE BLOCK AND PLATFORM. UPTURNED OUTLET IS IMMEDIATELY BEHIND HAWSER.

The pipe was made up partly on shore and partly on the lighters, in sections of 6 lengths, regular bell and spigot joints being used. (Fig. 2.) After having been made up, the section was closed by special heads at each end and a pressure of 50 lbs. air applied, a soap solution applied to the joints and any leakage which might show cared for. The pipe thus made up was laid from the lighters by being first suspended from a steel truss by chain slings under each joint brought to an even bearing by turnbuckles before hoisting, and a block of concrete 30 in. long by 15 in. wide and 6 in. thick, shaped to fit the pipe, suspended at each joint to form a bearing on the bottom. When all were fast, the truss and pipe were hoisted and the whole arrangement lowered to nearly the bottom of the trench. Here the spigot end of the pipe was guided into the hub already laid by the diver, a special device attached to bring home the ends of the pipe, and the other end of the pipe lined up by the engineer in charge, using, in deep water, ranges attached to the truss, and, in shallower water, the truss or the slings. After having been lined up, the pipe was laid to grade by soundings on the pipe, and when in proper position supports were built up under each joint with concrete blocks in addition to those attached at each joint, until a firm bearing was obtained. If excavation was necessary, as frequently happened, the material was pumped out, and if filling was needed, it was jetted in. In all cases, however, the concrete blocks were laid on firm, undisturbed bottom as a support for the pipe.

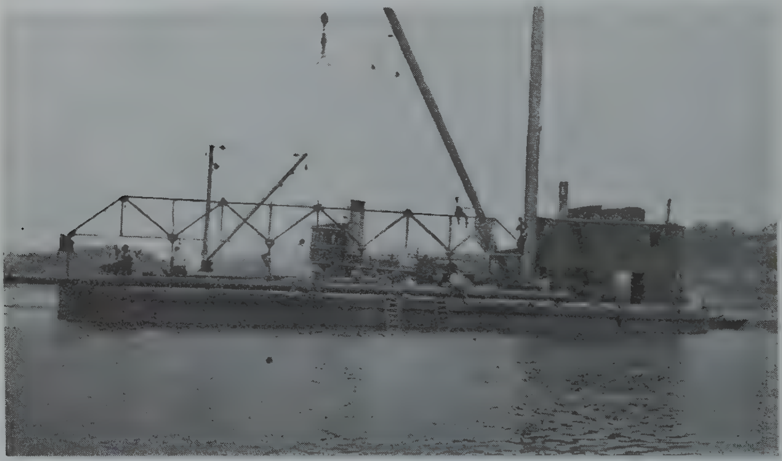

FIG. 2. CAST-IRON PIPE BEING JOINTED ON LIGHTER.

After several sections of pipe had been laid, and whenever the sea became too rough to lay pipe, the divers went down to make up the joints between sections. These were made with Juto-lead wool and strips of cold lead cut to a length to make the circumference of the joint, and hammered home by compressed air tools and by ordinary hand hammer and chisel.

This general method was pursued throughout the work without special difficulty except that due to occasional rough weather. Pipes meeting from two opposite directions were joined with the ordinary sleeve. Sections where a vertical curve was desired were made up to conform to this curve laid out on the deck of the lighter from soundings by the engineer in charge.

After a considerable section had been laid, the ends were sealed and hydraulic pressure from the pump of one of the tug boats applied in an endeavor to obtain our requisite 50 lbs. This we were unable to do and, to discover the leak, applied air pressure. This indicated the leak very quickly, as the surface of the water was examined along the line, and after an examination the diver reported that one length of pipe was split for a distance of about three feet on its side. To remedy this we obtained a special split sleeve at considerable delay and expense, and secured it around the injured pipe, calking it as securely as possible with cold lead. This was tested and found to leak. The diver then tried to take up the bolts at the joints, and split the sleeve. We then did what we should have done in the first instance. That is, we broke out the defective pipe and by using an ordinary sleeve laid in a new section of pipe. After this had been made secure, we again applied hydraulic pressure to the pipe of 50 lbs. per sq. in., and after this had been held by the line for two hours with a drop of less than 3 lbs., it was felt that it was secure.

As a result of this experience, we thereafter, in testing our sections, sealed the ends, applied air as before, and then suspended the entire section over the side just under water. We found in this manner occasional defective joints but no more split pipe.

This general routine was followed throughout the work, no special joints being used at any point. The soundings proved reliable, less than 20 yds. of ledge being found along the under-water trench. The greatest delay and most difficult work proved to be due to the short section where the line, to avoid the channel of the outer harbor, passed over a point of rocks and ledge between high and low water. Here the men from the lighters, who were splendid workers on water, somehow or other seemed lost on land, and the bulk of the excavation was performed by the laborers supplied by A. G. Tomasello, the contractor on the street work. The ledge, too, was quite seamy, and both steam and air drills were used, the latter with great effectiveness.

At two points along the outfall sewer are constructed blow-offs, one near the pumping station and one at the rocky point just described. These are for emergency use only.

The pipe was tested in short sections as laid, leaks being discovered as before described, and at completion the entire line was tested and the required pressure maintained successfully.

The entire length of the outfall as finally laid is 8 657 ft., and the cost, exclusive of engineering, was a trifle over $68 000. The entire system — including the street mains, pumping station and well, and the outfall — was constructed within the appropriation made, except for land damage, and cost approximately $220 000.

Mr. Charles A. Fritz, of this Society, was in charge of the outfall work, and I am indebted to him for much of the detail of this paper.

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BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

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EXTENSION OF THE NORTH METROPOLITAN SEWERAGE SYSTEM OUTFALL AT DEER ISLAND, BOSTON HARBOR.

By Clarence A. Moore.*

(Presented before the Sanitary Section, January 3, 1917.)

I appear before you through the courtesy of your Society and of Mr. F. D. Smith, chief engineer of the Metropolitan Sewerage Works, to endeavor to give you an idea of the extension work now in progress at the outfall of the North Metropolitan Sewerage System at Deer Island, Boston Harbor.

For the benefit of any who may not be familiar with the sewerage systems of the Metropolitan District, I will state briefly that this area is divided into three distinct sewerage districts: namely, the South Metropolitan district, serving the territory in general south of the Charles River; the North Metropolitan District, serving the territory north of the Charles River; and the Boston Main Drainage District, lying between the two already named.

Of these systems, we are concerned this evening with only that serving the North Metropolitan District, which includes the municipalities of Winthrop, East Boston, Chelsea, Everett, Malden, Melrose, Charlestown, Cambridge, Somerville, Medford,

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Note. Discussion of this paper is invited, to be received by W. L. Butcher, editor, 14 Beacon Street, Boston, before May 10, 1917, for publication in a subsequent number of the Journal.

* Assistant Engineer, Mass. Metropolitan Water and Sewerage Board, Boston, Mass.

Winchester, Woburn, Stoneham, Arlington, Belmont, Wakefield, a part of Lexington, Revere and Reading. The last-named town has been admitted but recently to this district, and the trunk sewer has not yet been extended to this town.

The sewage from this district, comprising the seventeen municipalities and the two districts of the City of Boston named and Deer Island, with an area of approximately 100.35 square miles and an estimated population of 621 700, is discharged through the Deer Island Outfall into Boston Harbor at a point about two hundred feet west of Deer Island Light. (Fig. 1.)

This outfall is on the southerly slope of Deer Island Bar, about 1 900 ft. from the Deer Island mainland and about 3 500 ft. from the Deer Island pumping station, where the sewage is lifted to an elevation sufficient to discharge it continuously against the varying tidal head. The outlet is one-half foot below mean low water; and discharges vertically; while the general direction of flow is toward the main ship channel, where strong currents tend to dissipate the sewage rapidly.

The existing outfall was placed at a time when such method of sewage disposal was practically untried, on a large scale, but has proven successful in so far as pollution of the shores is concerned. There has always been discoloration of the water in the ship channel for some distance, perhaps one-half mile, about the outfall. The outfalls of the South Metropolitan System, placed about nine years after that at Deer Island, are thirty feet below low water. The condition of the harbor water has been so much better around the outfalls of the South Metropolitan System than around other outfalls, that the Massachusetts Metropolitan Water and Sewerage Board is now seeking to improve the North Metropolitan System outfall by a similar submergence, with the added improvement of multiple outlets.

Complaints about the condition of the water surrounding the Deer Island outfall have been made by boating interests; and by officials of the United States government in view of the proposed use of the south end of Deer Island for military purposes, and because of the proximity of the Deer Island lighthouse, a structure not in existence when the outfall was designed.

The improvement of the Deer Island outfall, mentioned

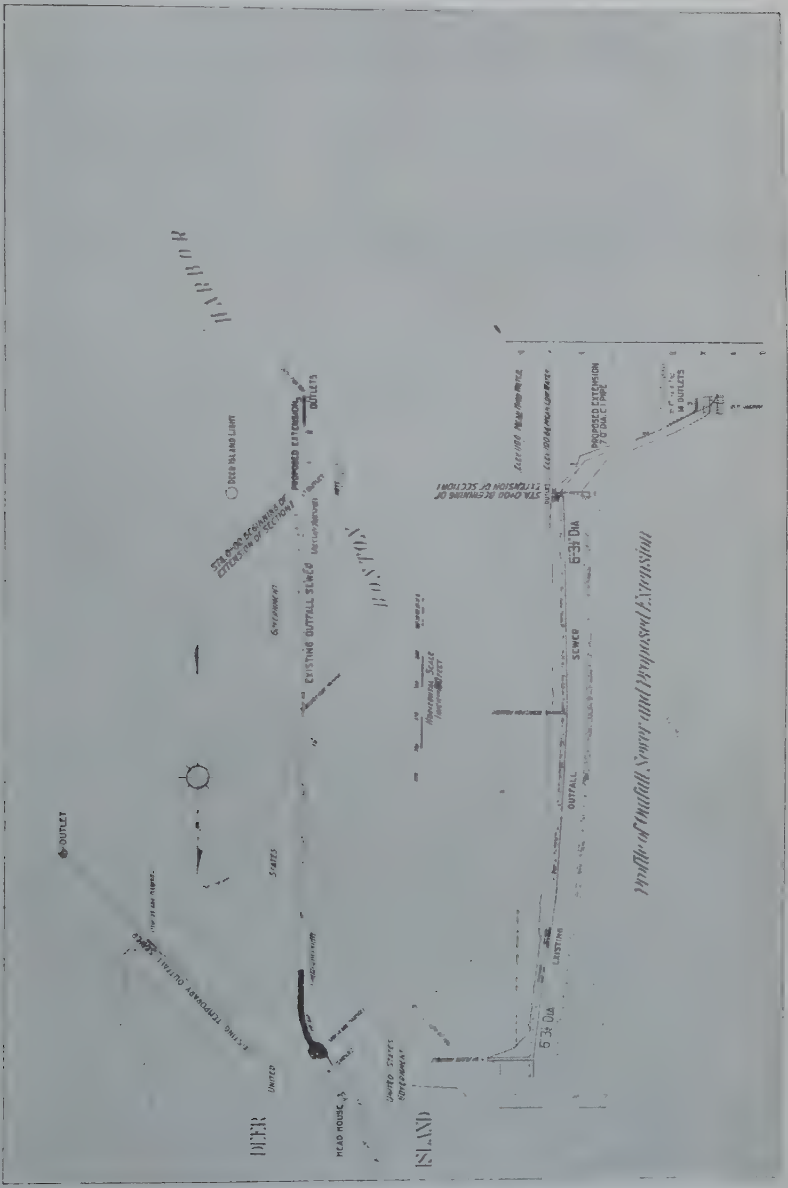
DEER ISLAND
BOSTON
HARBOR
OUTLET
EXISTING TEMPORARY OUTFALL
HEAD HOUSE
UNITED STATES GOVERNMENT
EXISTING OUTFALL SEWER
DEER ISLAND LIGHT
STA 0+00 BEGINNING OF EXTENSION OF SECTION 1
PROPOSED EXTENSION
OUTLETS
Horizontal Scale
Profile of Outfall Sewer and Proposed Extension
6'3" DIA
EXISTING OUTFALL SEWER
STA 0+00 BEGINNING OF EXTENSION OF SECTION 1
ELEVATION MEAN HIGH WATER
ELEVATION MEAN LOW WATER
PROPOSED EXTENSION 7'0" DIA C.I. PIPE
OUTLETS

FIG. 1. EXISTING, TEMPORARY AND PROPOSED SEWER OUTFALLS AT DEER ISLAND.

above, involves an extension of the existing sewer some 315 ft. (See Fig. 1.) To this extension the present paper is devoted.

For the first step, a temporary outlet had to be provided, so that the sewage flow might be diverted during the construction of the extension of the permanent outfall. This temporary line (see Fig. 1) was started at a point on the existing outfall sewer, about 200 ft. back from the high-water line on Deer Island. Here a double chambered stop-plank manhole was built, the chambers extending to the bottom of the old sewer, and a new branch was cut into it at an angle of 30 degrees.

From this manhole a 6 ft. 6 in. circular sewer of reinforced concrete was built, following in a general way the southerly shore-line of the island for a distance of 770+ ft. From a second manhole, located where this 6 ft. 6 ins. sewer ends, four hundred feet of 60-in. cast-iron pipe was laid partly in open, hand-excavated trench and partly in dredged trench. A 90-degree bend forms the outlet of this line, the opening being upward and some three feet below mean low water. This line was studied and designed with the expectation that it would at some time be extended to a point where the water is forty-five feet deep. With this provision of two outlets, the advantage of distributing the sewage over a considerably larger area will be gained.

Dredging was commenced July 9, in preparation for the extension of the old line. As no dipper dredge which could work to the required depth was available, the work was accomplished with orange-peel and clam-shell buckets. The material removed was almost entirely coarse gravel, although a little blue clay was encountered near lowest depth reached. Dredging was continued along the center line of the trench, no particular attention being given to the side slopes until sufficient depth was obtained.

An area 64 ft. by 20 ft. was dredged to about 58 ft. below low water, the outer end of this area being about 322 ft. south of the old outfall. From this area, the trench extended back to the existing outlet, the depth being such that reëstablishment of the original surface conditions after the pipe is in place will leave the pipe slightly covered to a point on the pipe a little north of the first outlet opening. From this point to the outer end, the grade of the pipe brings it gradually above the sloping ground. The water-line at the extreme end is about fifty-four feet below low water. (Fig. 2.)

In the sloping trench for a distance of 54 ft. from the level area described, single stones 6 ft. to 7½ ft. long by 4½ ft. wide by 2 ft. thick were laid firmly on the gravel bed of the trench as a foundation for each pipe. Two concrete sills 8 ins. by 12 ins. by 6 ft. were set upon each of these stones to adjust the pipe to required grade.

From this point to the old outfall, pile bents, of two piles each, spaced 6 ft. 0 ins. on centers, will be used as the work progresses. These bents will be 4 ft. 6 ins. apart and will be capped with 10-in. by 10-in. yellow pine timber. The change to pile foundation is due to the fact that the dredged trench becomes hardly more than a level bench on the side of the slope. It is considered that piles will afford a more secure support against lateral sliding.

Over the level area at the south end, mentioned above, a layer of granite chips was placed between Stas. 2+58 and 3+22 to even up irregularities left in dredging. On this bed, granite blocks 2 ft. in thickness were placed. Most of these blocks are from 12 to 15 ft. long by 4 ft. 6 ins. to 5 ft. 0 ins. wide. Some few are more nearly square, measuring about 9 by 7 ft. by 2 ft. thick.

On this foundation course, a second course of dimension granite blocks 2 ft. thick was placed. The stones in this course are so laid that the outer ends of adjacent stones are nea op- posite sides of the lower course, and the inner ends overlap under the pipe, forming a continuous layer. In this way spaces were left on either side of the pipe between alternate stones into which buttress stones 6 ft. 0 ins. by 5 ft. 6 ins. by 4 ft. 0 ins. were fitted. These buttress stones, placed against the pipe just back of the bells, secure the pipe against any lateral or longitudinal movement. The three outer buttress stones on the east side of the pipe location were set before the pipe was placed.

The 84-in. pipe, with specials, was furnished under contract by the United States Cast-Iron Pipe and Foundry Company, of Burlington, N. J. They were brought to South Boston by rail, lightered to the Deer Island shore, and landed on the beach

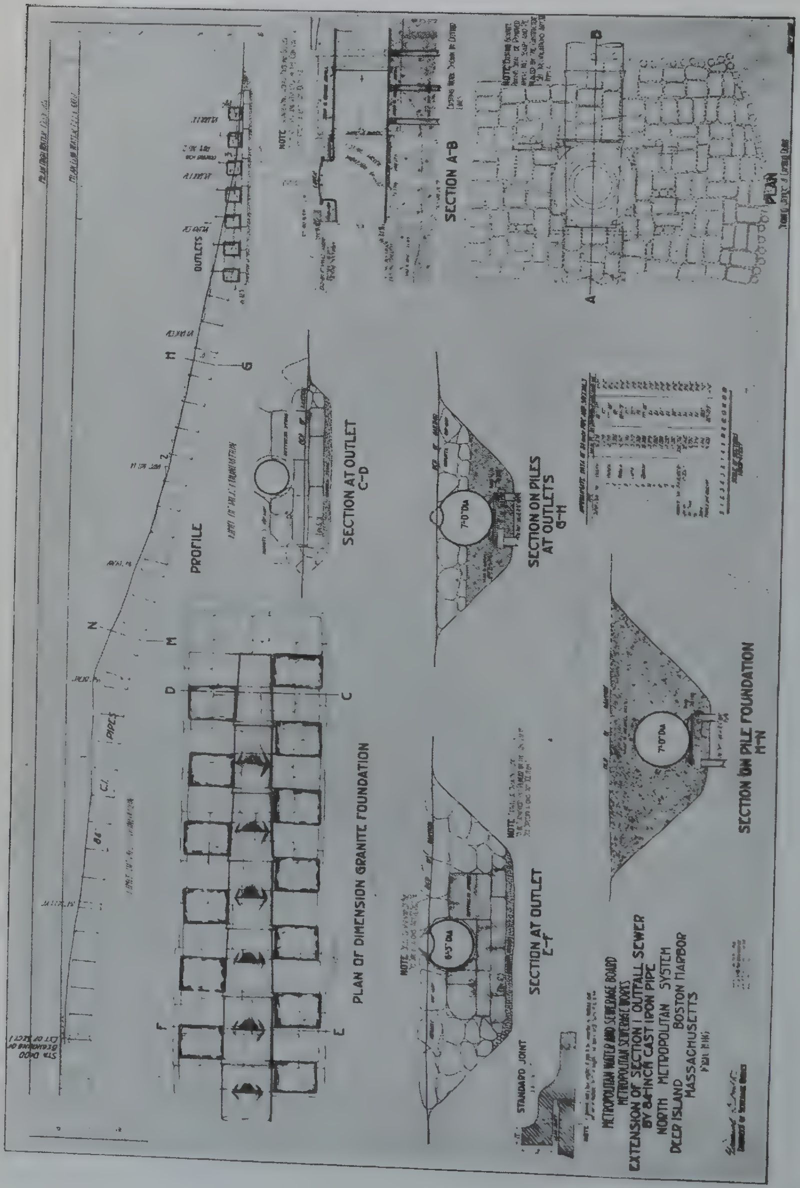
PROFILE
OUTLETS
PIPE
C.I.
SECTION A-B
PLAN
A
B
SECTION AT OUTLET C-D
SECTION ON PILES AT OUTLETS G-H
7'-0" DIA
PLAN OF DIMENSION GRANITE FOUNDATION
C
D
E
F
G
H
M
N
SECTION AT OUTLET E-F
6'-5" DIA
SECTION ON PILE FOUNDATION M-N
STANDARD JOINT
NOTE
METROPOLITAN WATER AND SEWERAGE BOARD
METROPOLITAN SEWERAGE WORKS
EXTENSION OF SECTION 1 OUTFALL SEWER
BY 84-INCH CAST IRON PIPE
NORTH METROPOLITAN SYSTEM
DEER ISLAND BOSTON HARBOR
MASSACHUSETTS

Fig. 2. Proposed Sewer Outfall at Deer Island.

at high water. (Fig. 3.) The pipes, which are in 9-ft. lengths, are 2 ins. thick and have bells 6 ins. deep. The standard pipes weigh about 17 000 lbs. each. The heaviest piece, a reducing tee 75 ins. by 84 ins. by 75 ins. and 11 ft. long, which is to make the connection with the existing structure, weighs 24 980 lbs. Twenty-three of these pipes, including all those having outlet openings, were coated externally with "Bitumastic" enamel while on the Deer Island shore. The object of this treatment is to protect the more directly exposed pipe from the action of salt water.

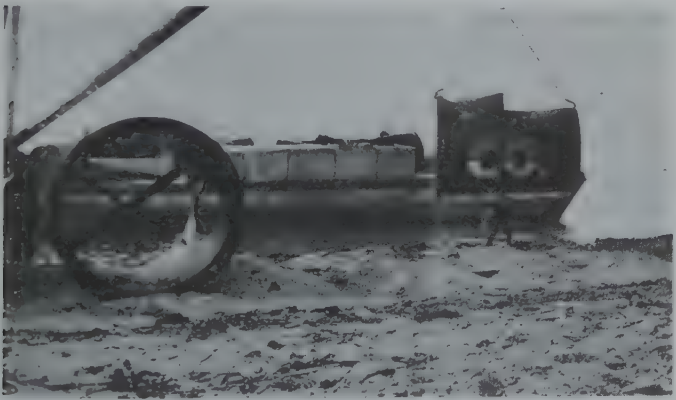

FIG. 3. 84-IN. PIPE LANDED ON THE BEACH AT DEER ISLAND.

To lay the pipes, six at a time were taken aboard the lighter of the contractor, Roy H. Beattie, Inc., and made together on blocking into three-pipe sections, the joints being leaded. These sections were handled by being slung from a strongback in straps of wire rope by the derrick boom of the lighter.

In placing the sections, the lighter was secured to permanently established mooring lines and drawn into position above the prepared foundation. The pipe was then lowered on to the concrete sills placed by the divers, adjusted to required grade, and securely blocked. The outermost two sections were placed in this manner on the heavy stone foundation, and the remaining buttress stones were set in position.

The third section, consisting of two straight pipes and a curve, as may be seen from the profile (Fig. 2), extends beyond the heavy stone foundation described and is laid with considerable slope, about 1 to 4½. It is obvious that, to lay the pipe on this slope without danger of displacing the sills, the pipe must be lowered in a sloping position so that the spigot end can be inserted in the bell of the previously laid pipe before the other end comes to a bearing. To accomplish this, the contractor provided a special strongback formed of two 15-in. channels riveted together, with separators between. Three hanger plates are riveted to the sides of each channel, and to these hangers are attached straps of wire rope. (Fig 4.) In slinging the pipe, the free end of these straps is hooked into the eye of a turnbuckle suspended from the hanger at the other side of the strongback. This affords a very convenient method of tightening the straps.

Near either end of the strongback is a pin 3 ins. in diameter, around which is passed an endless, heavy wire cable. The two strands of this cable pass through a yoke, the position of which can be adjusted before the apparatus is brought under tension. Under tension, the yoke is clamped rigidly in position. By trial, the position of this yoke is so established as to give the required slope to the pipe, and the suspended section is then lowered to place.

The joints between the sections were calked by the divers with lead wool with ordinary calking tools. A strip of lead cast 6 ins. wide by ½ in. thick, and of sufficient length to extend around about one third the perimeter of the pipe, was placed in the lower part of the bell of each slip joint. This served to keep the spigot end up in alignment and to reduce the amount of calking required at the most difficult part to reach. In addition to the lead so placed, each joint required about 150 lbs. of lead wool, and consumed about two days' time for completing the calking. One diver would usually be calking joints while the other was at work preparing the foundation to receive another section. During the period of strongest tidal current, when material could not be lowered, both divers worked on the joints.

Owing to the very exposed location of this work, there was necessarily much lost time. The unusually stormy spring and summer, with much foggy weather, was especially unfavorable, and work other than dredging was not started until about September 20. The swift currents and frequent heavy undertow encountered in this location rendered the placing of material other than rough stone for riprap work impossible except at slack water on days when there was no considerable undertow.

When it became necessary to suspend work on account of weather conditions, four sections of pipe (108 ft.) had been placed. Two of these sections were laid on the heavy stone foundation with but little slope, and the other two were laid on the incline. Blocks of broken granite and granite chips have been placed under and around these pipes and between the buttress stones, forming a defense extending about twenty feet on either side of the center line and rising to the general grade of the top of pipe. No backfilling has been done about that portion of the line where the fourteen outlets are located with any fine material which might be washed from place. The inshore end of the pipe and the three outlet openings in the section last laid are bulkheaded, to prevent filling with gravel during the winter.

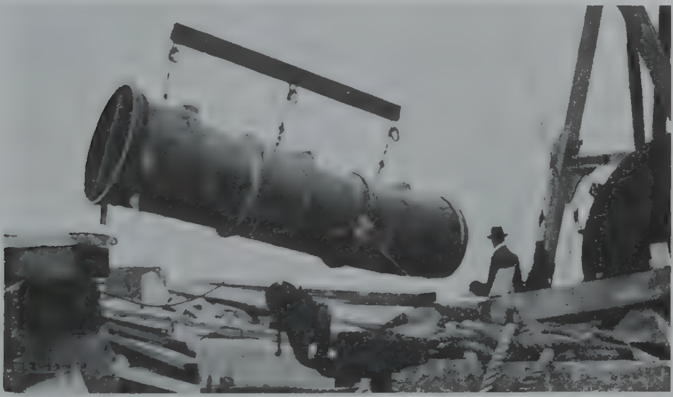

FIG. 4. METHOD OF LAYING PIPE ON A SLOPE.

When work is resumed in the spring of 1917, the pipe laying will continue toward the existing outlet on a pile bent foundation to the point where the sleeve is shown. (See Fig. 2.) The existing outfall will be broken out and the reducer tee 75 ins. by 84 ins. by 75 ins. will be connected into the existing channel. The branch will be capped and the pipe will be extended to meet the pipe laid from the outer end. The closure will be made with a sleeve as indicated on the drawing, two pipes having both ends spigots being utilized for this purpose.

The discharge under the new conditions will be from fourteen outlet openings, increasing in size toward the outer end. The diameters of these openings, which are approximately elliptical, with the exception of the outermost, which is a 48-in. circle, vary from 25 and 44 ins. to 13 and 23 ins. respectively. The reduction from 84 ins. to the 48-in. terminal outlet is accomplished in seventy-two feet by making alternate pipe into reducers, the reduction in each being nine inches.

The design of the pipe was determined as the result of studies for different conditions of tidal head and flow. The areas of the several openings are proportioned so as to discharge as nearly equal quantities as possible.

While the sewage will inevitably come to the surface, due to the difference between its specific gravity and that of sea water, it is confidently expected that the greater opportunity for dissipation and dilution before the surface is reached, with this scheme of distributed discharge under a considerable depth of water, will result in materially improved appearance of the water about this portion of the harbor.

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BOSTON SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

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DISCUSSION OF "EFFECT OF CHANNEL ON STREAM FLOW."

By C. H. Pierce, Dwight Porter, D. M. Wood, R. A. Hale, H. K. Barrows and N. C. Grover.

Mr. Pierce.* — There is one phenomenon very closely related to the subject of Mr. Grover's paper which I believe has not been fully covered, and that is the effect of ice in destroying the stage-discharge relation which exists during the open-water period. A rating curve may be defined by a series of discharge measurements having a high degree of accuracy, but as soon as ice forms to any appreciable extent the channel conditions are changed and the rating curve is no longer applicable. In a section of the country where ice may exist from November to April, the minimum flow for the year possibly occurring during this period, the collection of winter records becomes a problem in itself. As in many other problems of hydraulics, the solution has been found by experiment and experience, rather than from theoretical deduction.

It may readily be seen that the amount of backwater at the gage, that is, the increase in gage reading over what it would be under normal conditions, does not remain the same throughout the winter, but varies with the nature of the ice formation. In general, the backwater begins with the formation of shore ice or by ice freezing on exposed rocks at the control, although in some cases "anchor" ice and slush ice may be the first disturbing feature. There is often a sudden rise succeeded by a fall, after which the backwater gradually increases as the stream becomes covered with ice and as the ice increases in thickness. This may be explained by a decreased area in effective cross-section of the channel and by the formation of ice on the control. If the ice remains in place throughout the winter, with no break-up or ice jam, it is possible with a few discharge measurements and a careful study of temperature and precipitation records to make a correction for the backwater and secure what may be called "effective gage heights," to which the open-water rating curve is applicable. This correction is best made graphically (Fig. 1) by plotting the results of discharge measurements and obtaining a backwater curve which is subtracted from the observed gage height graph to secure the effective gage height graph. In determining the backwater curve, the thermograph or temperature record and the precipitation are carefully studied to see that the results are consistent.

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* District Engineer, United States Geological Survey, Boston.

If the ice conditions do not remain stable throughout the winter, but are interrupted by break-ups and ice gorges, the work of making winter estimates becomes more complicated and a larger number of discharge measurements are needed.

One point should be emphasized in connection with this feature of the work, and that is, the selection of the site for the gage. If a site is selected with reference to its adaptability for winter work it may be possible to secure better results at less expense than would otherwise be the case.

A very full discussion of the effect of ice on stream flow may be found in Water-Supply Paper 337.

PROFESSOR PORTER.* — I should like to ask how near above the artificial control the gaging station is usually placed. I thought it appeared to be but very little above in two or three of the lantern views.

MR. GROVER. — In many cases, yes. In streams that carry a great deal of débris it is practically necessary to put the artificial control very close to the gage, otherwise the bars of sand and gravel and other drift will cause a secondary shifting control to be built between the gage and the control, so that the value of the control is lost.

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* Professor of Hydraulic Engineering, Mass. Inst. of Technology.

PROFESSOR PORTER. — For many years and until rather recently, the civil engineering students at the Massachusetts Institute of Technology were given practice work with the rod type of current meter on the Charles River at Newton Upper Falls, and afterwards on Mother Brook at Dedham. Being interested to see how the gagings of a series of years would show up on a station rating curve, I had them plotted for the Charles River at Newton Upper Falls, but the points proved much too scattered to give a definite curve. The first thought was that this might be due to errors in the work of the students, as they

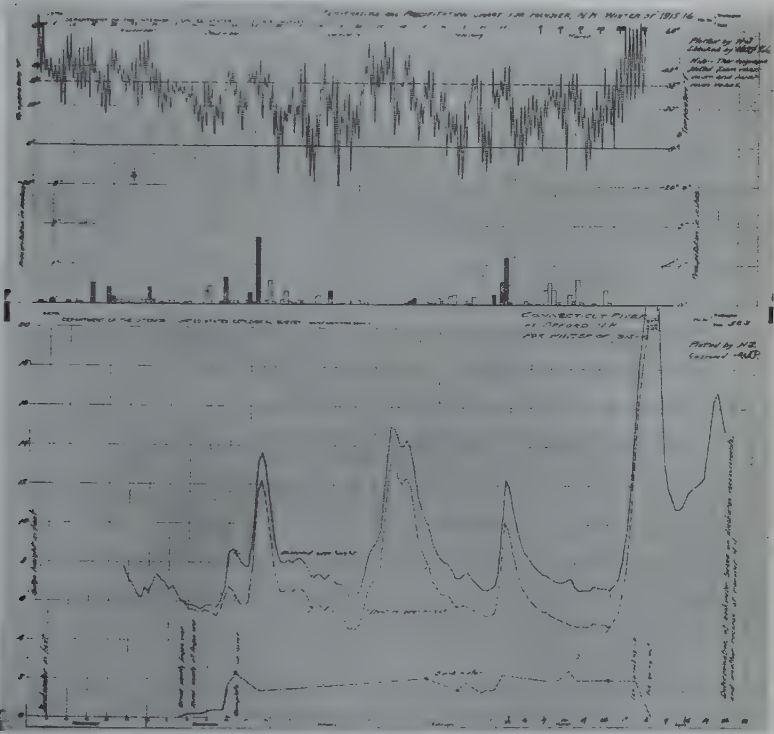

FIG. 1. GRAPHICAL METHOD OF DETERMINING BACKWATER FROM ICE.

were all beginners. Nevertheless, the conditions were favorable for good work and the gagings were closely supervised, and I later suspected that the difficulty was not so much due to unskilled work by the students as to obstruction of the stream at and below the point of measurement by a thick growth of aquatic plants, which Mr. Grover has mentioned as sometimes a disturbing cause. There was such a growth here, which very likely varied from year to year and which was sometimes cut away for the purpose of removing the obstruction to the flow of the stream. That the irregularity shown by the plotted points was probably not due to faulty work by the students, was indicated by the fact that for the Mother Brook gagings, carried on in precisely the same way as those on the Charles, a very smooth station rating curve was found.

MR. WOOD.* — The Geological Survey engineers are pioneers in the technical development of the theories and methods of stream gaging in this country, and it is difficult for others not engaged constantly in such work to suggest new points of view. In the paper under discussion, a summary of many fundamentals evolved from field studies covering many years has been concisely and clearly presented.

The title of the paper might possibly be amended by the addition of the word "Measurement" or "Determination," since Mr. Grover's argument is devoted to the effect of natural or artificial conditions upon the accuracy of the determination of the amount of water flowing past a given gaging section.

It would appear that Mr. Grover's remarks might logically be grouped under two headings: (1) the effect of channel at or near the gaging section; and (2) the effect of the "point of control." It is very surprising to learn how much the second overshadows the first in importance.

Nevertheless, the conditions *at* the gaging section will usually influence to a great extent the selection of the site. Some of the factors to be considered may be listed as follows:

(A) *Channel Conditions.*
  1. Permanence of the section.
  2. Roughness of the section.

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* With Stone & Webster Engineering Corporation, Boston.

3. Character of the current,—i. e., measurable range in velocity from 0.5 to 15± ft. per second, no serious eddies, lines of flow at right angles to the measuring section, etc.
4. Free gravity flow,—i. e., no erratic back water from tributary streams below or from dams, aquatic plant growths, ice or log jams.
5. The possibility of securing a suitable location for the gage.

(B) *Desirability Conditions.*

1. Accessibility.
2. Availability of structures for gaging purposes.
3. Reliability and cost of gage reader.
4. Possible regulation of water at points upstream; also possible diversions.
5. Annual operating costs.
6. Desirability and need of gagings.

The accuracy of the determination of the rate of discharge is dependent upon both the accuracy of the gage readings and the accuracy of the current meter measurements. The first depends upon the conditions described so well in the paper, but the last is dependent more upon the conditions at and above the measuring section than below it.

The extreme range from minimum to maximum of both stage and discharge is so great for the majority of our streams in this neighborhood that it is difficult to construct a gage that will give the desired accuracy except for a portion of the range.

The current meter itself will give nearly perfect accuracy under conditions of absolutely uniform flow, but, as Mr. Grover briefly stated, when the flow is at all irregular in direction with reference to the gaging section, some types of meters will over-register while others will under-register. In cases of non-uniform flow, no meter yet developed will accurately measure the rate of discharge under all conditions. The small Price meter, as improved by the Geological Survey, is the best adapted to general stream gaging work, but it is a question whether or not it should be held rigidly in a horizontal plane.

In the average stream, especially in this locality, the river channel at and above the measuring section is more or less rough. A bowlder located some distance upstream will often introduce irregularities of flow at the section.

The point of control itself, unless artificial, is not likely to be absolutely uniform across the entire channel, and this may, and often does, introduce irregularities of flow at the section.

It would, therefore, appear that the question of effect of channel on the accurate determination of discharge is connected intimately with the development of an accurately reading gage and a type of meter that will register correctly under all conditions of flow. Some of the factors, of importance now, will of course become of less importance if an accurately recording meter is developed.

Certain studies, not as yet made public, would indicate that such an ideal meter may sooner or later be found. Indications are that it will be of the horizontal or propeller type.

Now that the question of channel conditions has been so thoroughly studied, it would seem that the next step would logically consist of further experimental work on the behavior of different types of meters under angular velocity conditions, as a step toward the perfection of the meter.

About two years ago, the writer had charge of the hydraulic measurements in some turbine tests where the angular velocity conditions were in some cases very marked. He experimented with three types of meters, five meters in all. Three were small Price meters, one of which was wired to prevent tipping in a vertical plane. All meters were interchanged throughout the tests and comparisons indicated that one type over-registered as much as 10 per cent. in some cases, while another type under-registered 2 or 3 per cent. The small Price meter, which was wired to prevent tipping, apparently gave the most accurate and consistent results, although unfortunately they were not conclusive because of the usual lack of time and appropriations for the work.

MR. HALE.* — Regarding the Merrimack River at Lawrence, Mass., there is a gage in the river about a mile below the dam, known as the Lower Locks gage, which serves as an excellent index for a rating curve of discharge. There are no dams between this gage and the mouth of the river at Newburyport. About six miles below the gage, Mitchells Falls is situated, the upper end of which acts as a controlling point in the flow. The tides flow part way up on the falls and there is a free discharge to the mouth of the river. In the various stages of heights of river the surface slopes are nearly parallel, showing that the increased cross-sections practically provide for the increased quantities, and a fair rating curve is obtained.

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* Prin. Asst. Engineer, Essex Water Power Co., Lawrence, Mass.

There are some differences noted in the comparison of gage heights and quantities of water flowing, depending on whether the river is rising or falling, due probably to changes in the sections, but these differences are small. During the winter, with ice covering the surface, the water stands one or two feet higher at the gage than with the corresponding quantities in the summer time, and corresponding corrections must be made in the rating curve.

The quantities are usually determined from the flow over the dam and the quantity drawn by the mills for the most of the year, and the rating curve is used but a very small part of the time and some years not at all. The daily variation in the quantities flowing is considerable. During the working hours of the day about 5 000 sec.-ft. is drawn by the mills, and at other times about 2 000 sec.-ft. is drawn by the mills for electric lighting and by such mills as require water for twenty-four hours.

I consider it of great importance to have a first-class recording gage at the rating stations of the various rivers, in order to determine the flow throughout the twenty-four hours. When one gage reading is taken during the day, the flow at that time is ascertained, but no knowledge is had of its relation to other periods of the twenty-four hours. With various dams located on a river using water for ten and twenty-four hours power, variations in river heights exist that make it essential to have continuous readings. In the natural flow of a stream this difference may not be so marked, but it is important to know this relation which exists.

Mr. Grover. — We are all looking for a good pressure gage, that is, a pressure gage that is dependable. The great advantage of the pressure gage is obvious in the decreased cost and the ease and speed of installation, and if a pressure gage can be developed that will give sufficiently accurate results for a portion of the work even, it will be of great value. Many stations are maintained where approximate records are all that could be expected or desired, and it is believed that the field for a good pressure gage would be quite extensive, not only in the special work that Professor Sanborn first took up in the design of his gage, but in general stream gaging.

MR. HALE. — I would say that at Lawrence we have been using a pressure gage for over a year and we have had very good success with it. The scale is rather large, and it can be read to within one or two hundredths of a foot and agrees very closely with the scale set in the canal for comparison, and it has given very good satisfaction. We have placed a kerosene lamp in extremely cold weather in the box where the recording instrument is located, and the diaphragm has thus been kept free from ice and has given satisfactory results during the cold weather.

PROFESSOR BARROWS.* — Mr. Grover's paper has brought out clearly the fact that the "control method" of measuring streams, carried on by the Geological Survey, is similar in principle to that of using a weir. The artificial control in the stream is comparable to the weir, and as no weir formula will give the discharge accurately it is measured with a current meter at different heights and the "weir" rated. When the quantity of water flowing is so small that it becomes difficult to make an accurate measurement with the current meter, the construction of a standard weir, for which a definite discharge formula is known, may become preferable. A stream of small discharge is very easily affected by temporary obstructions, such as floating leaves or ice, and may require many current meter measurements and such close supervision that the cost will exceed that of weir measurements. On the other hand, in connection with other investigations, surveys, etc., in the vicinity of the gaging station, it may be possible to get the record of flow more economically by the current meter method than by constructing a weir.

Perhaps it is not out of place at this time to speak of the work which the Geological Survey is carrying on and the extent to which the states are coöperating with the national government. Many are probably not aware that the national appropriation for this work is very small, and in many cases it is only possible to accomplish substantial results by coöperating with the states.

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* Associate Professor of Hydraulic Engineering, Mass. Inst. of Technology.

The state of Massachusetts has been contributing to this work of stream gagings for the past five years, to the extent of three thousand dollars per year. A tangible result of this coöperation is a report upon "Surface Waters of Massachusetts" (Water Supply Paper No. 415), recently issued by the U. S. Geological Survey, which contains much new and valuable information in regard to the water supply of the state.

One who has occasion to make use of stream flow data is struck at once by the dearth of specific information along these lines. In the eastern part of the state, for instance, one finds the long and accurate record kept on the Merrimack at Lawrence, which data are, however, for a large stream and not usually well applicable to questions of water supply on smaller streams. The records of the Metropolitan Water Board on the Sudbury and Nashua rivers, while carefully kept, are on streams in both cases with large reservoirs and consequent large proportion of water surface, where the results are practically good only for use in periods of a month at a time, owing to the large corrections necessary for storage. Obviously, such records are of no service in considering flow by days, and as a matter of fact there are few records of any great length of time in this part of the state which are of use in predicting the water supply of small streams.

Water Supply Paper No. 415 is an excellent beginning, however, and it is to be hoped that the state and the U. S. Geological Survey will continue steadily on this valuable work and extend its scope if possible. Every opportunity should be utilized by engineers to commend to Congress and to the state legislature the value of these investigations.

MEMOIRS OF DECEASED MEMBERS.

THOMAS FRANKLIN RICHARDSON.*

DIED DECEMBER 26, 1915.

THOMAS FRANKLIN RICHARDSON was born in Woburn, Mass., on February 10, 1855. Mr. Richardson was descended in the eighth generation from Samuel Richardson who came to this country from the south of England, about the year 1630, with two brothers, Ezekiel and Thomas. Samuel Richardson and his wife became members of the church in Charlestown which subsequently became the First Church of Boston. Some two years after, a distinct church was organized in Charlestown which became the First Church in that place. In 1640, the three Richardson brothers, with four others, organized a new church in what was then the limits of Charlestown but was established as the separate town of Woburn. The original town of Woburn included much of what is now Winchester, some of Wilmington and a portion of Stoneham. The Samuel Richardson home was located within the present limits of Winchester. The second house built on this site nearly two hundred and fifty years ago remained practically in its original condition until a year or two ago, when it was destroyed by fire.

Mr. Richardson graduated from the Boston English High School in 1872.

Mr. Richardson commenced his engineering work in May, 1873, as rodman on the investigation and construction of the aqueduct, sixteen miles long, built mainly of brick and rubble masonry, having a capacity of 110 000 000 gals. per day, of the Sudbury Water Works for the city of Boston. At the close of this work in May, 1878, he held the position of instrumentman on a construction party.

From November, 1878, to October, 1879, he was assistant engineer for the city of Chelsea, Mass., engaged in general city work, particularly having charge of the construction of a brick trunk sewer.

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* Memoir prepared by Hiram Allen Miller.

In November, 1879, he entered the engineering corps of the Atlantic & Pacific Railroad (now part of the Santa Fé system). He was first topographer on the surveys for the location of the line and subsequently had charge of some twenty-five miles of railway construction, partly in New Mexico and partly in Arizona, as superintendent as well as engineer. This work included two bridges, the Padre Canon and the Canon Diablo. The Canon Diablo Bridge was a notable piece of construction for that time, being a steel trestle having the extreme height of some 225 ft. and a length of 600 ft. All this work was very difficult, labor conditions being unusually bad, and it was necessary to haul water for construction purposes for a distance of twenty-five to thirty miles, largely by teams. His connection with this road ceased in June, 1882.

In September, 1882, he entered the engineering corps of the Mexican Central Railway, remaining with this company until July, 1885. His work included the construction of the Encarnacion Bridge, 175 ft. high and 1 300 ft. long, situated some three hundred miles north of the City of Mexico. This bridge was larger than any other bridge that had been constructed in Mexico at that time. Mr. Richardson designed the masonry for the abutments and pedestals, and superintended the erection of the iron work, which was done mainly by Mexican laborers, it being necessary to educate these laborers to drive rivets and do similar work. For about a year he was bridge engineer on the southern half of this railroad, and for a year was resident engineer on the northern six hundred miles of the railroad, designing and laying out the masonry for a large number of bridges.

From September, 1885, to June, 1886, Mr. Richardson was division engineer on the construction of the Chicago, Burlington & Northern Railroad in Wisconsin, having charge of the timber trestle work across the Wisconsin River and some heavy grading work.

From July, 1886, to April, 1887, he had charge of railroad surveys, designs of structures, and estimates in the mountains between Glenwood Springs and Aspen, Colo., for the Colorado Fuel Company in the development of their coal properties. Here he located a number of railroad lines with grades as high as five per cent., using switchbacks on several of the lines.

From May, 1887, to December, 1888, he was division engineer on the construction of the Atchison, Topeka & Santa Fé Railroad, in charge of the division yard at Chillicothe and the heavy work near the Illinois River, and for most of the last year was resident engineer in charge of all new work in the state of Illinois.

From January to April, 1889, he was engaged on location work for the Denver & Rio Grande Railroad, locating a line in the San Luis valley from Villa Grove to Alamosa.

Between April, 1889, and January, 1892, he was chief engineer of the construction and location of the Manitou and Pike's Peak Railroad, designing all the structures and working out the necessary appliances for laying the rack rail. The maximum grade of this railroad is 25 ft. per hundred, maximum curvature 16 degrees. The Abt rack rail was used. This railroad is 9 miles long and extends from an elevation of some 6 000 ft. to an elevation of 14 100 ft. above sea level. About 3½ miles of this road are above the timber line.

From February, 1892, to March, 1893, he was with the Sanitary District of Chicago as assistant engineer, having charge of the construction of several miles of the Lemont portion of the main channel, 160 ft. wide and something over 30 ft. deep.

From April to August, 1893, he was engineer in charge of the Sixty-Eighth Street tunnel for the city of Chicago. This is one of the water tunnels of the city of Chicago extending four miles under Lake Michigan. It was built of brick through clay and silt, and quite difficult of construction; on a large portion of it compressed air was used.

In August, 1893, he returned to Massachusetts, and from that time until June, 1895, had charge of all the surveys for reservoirs and aqueducts for the State Board of Health, in connection with the investigations for a water supply for the Metropolitan District, and made preliminary designs, locations and estimates of cost. The work included the location of the Wachusett aqueduct, 12 miles long, having a capacity of 300 000 000 gals. per day; the Wachusett reservoir, having a capacity of 65 000 000 000 gals.; the Wachusett dam and different structures connected with the same; the location of a reservoir on the Ware River, capacity of 11 190 000 000 gals., and a tunnel 8.7 miles long connecting this reservoir with the Wachusett reservoir; the location of a reservoir on the Swift River, having a capacity of 406 000 000 000 gals., and of a tunnel 27.6 miles long, connecting this reservoir with the Wachusett reservoir; and the location of the Weston aqueduct, length about 13½ miles, capacity 300 000 000 gals. per day. He also made a study of other sources of supply.

From July, 1895, to January, 1906, he was engineer of the Dam and Aqueduct Department of the Metropolitan Water Works, in charge of the construction of the Wachusett aqueduct, 12 miles long, built largely of concrete, including one tunnel 2 miles long, and a masonry arch bridge some 400 ft. long over the valley of the Assabet River. In this connection he had charge of the sewage treatment plant for taking care of the sewage of the town of Clinton, including a power station for pumping the sewage and about 25 acres of filter beds. He also had charge until May, 1896, of studies for the location and design of the North Dike, and of the land surveys for the Wachusett reservoir. His work included the relocation of the Central Massachusetts Railroad from Berlin Junction, where it passes over the New York, New Haven & Hartford Railroad, to the North Dike, including a steel viaduct about 1 000 ft. long and 135 ft. high across the Nashua River below the dam. He made the final location of the Weston aqueduct, on which are one tunnel, 1 mile long, and two tunnels, each about ½ mile long, two shorter tunnels and also nearly a mile of steel siphon pipes 90 ins. in diameter. He was in charge of the investigations for the Wachusett Dam and all construction work connected with it, including a large amount of excavation at the site of the dam, which was done by day laborers. Mr. Richardson was also engineer of the Reservoir Department in 1905.

From January to March, 1906, Mr. Richardson was construction superintendent for the J. G. White Company, Inc., in charge of the Laguna Dam near Yuma, Ariz., for the Reclamation Service of the United States.

From March to July, 1906, he was again connected with the Metropolitan Water Works as engineer of the Dam and Reservoir Department.

From July, 1906, to July, 1907, he was resident manager in charge of the construction of the plant of the Rockingham Power Company on the Peedee River, at Hamlet, N. C.

In September, 1907, Mr. Richardson was again associated with the J. G. White Company, Inc., and placed in charge of the La Crosse water power development at Hatfield, Wis., returning to New York late in December of the same year. On January 1, 1908, he was appointed general superintendent of construction, in general charge of contract work for the New York office. As general superintendent he had charge of hydro-electric work as follows: La Crosse Water Power Company's development at Hatfield, Wis.; Connecticut River Power Company's development near Brattleboro, Vt.; the Central Georgia Power Company's development at Jackson, Ga.; the Idaho-Oregon Light & Power Company's development at Copperfield, Ore.; and the Minnesota-Ontario Power Company's development at International Falls, Minn.; and also the Idaho Irrigation development in the vicinity of Richfield, Ida.

These hydro-electric developments were all approximately 20 000 h.p. in size, and the irrigation proposition covered 150 000 acres. He held this position until September 1, 1909, when he was made chief civil engineer of the company. In this position he made numerous investigations, studies and estimates for power developments, etc., and was used by the J. G. White Company, Inc., as consulting expert on engineering matters. While in this position Mr. Richardson acted as consulting engineer in connection with the Fellsmere Farms Company's work of reclaiming 115 000 acres of land in Florida.

Mr. Richardson held this position until the engineering department of the J. G. White Company, Inc., was taken over by its subsidiary, The J. G. White Engineering Corporation, January 1, 1913, at which time Mr. Richardson automatically became civil engineer of The J. G. White Engineering Corporation. He held this position and was occupied on reporting and consulting duties until August 1, 1914, when he resigned on account of failing health. He was, however, able to do some consulting work after that date.

For over forty years he was continuously engaged on engineering work, and acquired a valuable experience on the construction of railroads, water works, hydro-electric plants and irrigation and drainage projects. His work, extending over all portions of the country, has made him well-known throughout the United States as a capable engineer, an energetic executive, and as a faithful and honest man.

Mr. Richardson was married on October 4, 1888, to Miss Nellie Symonds who, with three sons, survives him.

Mr. Richardson was elected a member of the Boston Society of Civil Engineers on March 21, 1894. He was also a member of the American Society of Civil Engineers, the New England Water Works Association and the Engineers' Club of New York City.

EDWARD D. BOLTON.*

EDWARD DAVIS BOLTON was born in Somerville, Mass., October 14, 1849, and died at New York, March 10, 1916.

He was the son of John B. and Sarah A. (Davis) Bolton; was educated in the public schools of his native city and the Massachusetts Institute of Technology.

Leaving the Institute in June, 1868, he entered the office of S. L. Minot, C.E. (in the old Barristers Hall, Boston), where he was employed in general railroad work on the Old Colony, Boston & Albany and Boston & Providence railroads, and in surveys and construction of various branches and additions to these railroads.

He remained with Mr. Minot until February, 1875, when he entered the office of Ernest W. Bowditch (then Bowditch & Copeland), of Boston. Here he was engaged in a large variety of work of general engineering, landscape work, sewerage and water works, and had general charge of the office during the absence of Mr. Bowditch in Europe.

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* Memoir prepared by Frederic M. Hersey and Daniel W. Pratt.

In March, 1888, he left Mr. Bowditch and entered into the business of general contracting for engineering work with Mr. T. William Harris, and later for himself in contracting and engineering work. From April, 1891, to July, 1892, he was with the Cataract Construction Company; and in July, 1892, he went with Olmsted, Olmsted & Eliot as superintendent of construction.

He remained with Messrs. Olmsted for three years or more, when he went to New York and was employed for several years in the public works of Brooklyn, as assistant engineer in the department of sewers, in which latter work he was engaged at the time of his death.

Mr. Bolton's father was an expert steel engraver, and the same talent was evident in the work of the son, who was a superior draughtsman as well as engineer.

When a student at the Institute of Technology, his associates speak of him as "a young man of gentle bearing and quiet, unassuming manners; of slender physique, but with abundant strength of character, diligent and faithful in all things and a true friend to his fellows."

His associates in later years feel that his promise as a student was fulfilled in his life work — leaving a record for ability, honesty and integrity.

He joined the Boston Society of Civil Engineers October 21, 1896.

Mr. Bolton married Dora M. Lovering, and is survived by her and two sons — Harold L. Bolton, of East Orange, N. J., and Ernest D. Bolton, of Hillsdale, N. J.

FRANK EDSON SHEDD.*

Frank Edson Shedd was born in Sharon, N. H., on July 18, 1856. He attended the Conant High School of East Jaffrey, N. H., and entered Dartmouth College, from which he was graduated in the Class of 1880.

After a year of teaching, as principal of a high school, Mr.

---

* This memoir, originally prepared by Mr. Frank W. Reynolds for the American Society of Civil Engineers, is submitted with certain minor changes by Mr. Chas. T. Main.

Shedd entered the service of the United States Coast and Geodetic Survey, where he remained for a year, his work being on the charting of the coast of Maine. In 1882, he left the service of the Government to take up civil engineering in Lowell, Mass.

In 1886, Mr. Shedd had charge of the erection of the Washington Mills, at Lawrence, Mass., at that time one of the largest mill construction propositions which had ever been undertaken. These mills are now owned by the American Woolen Company.

In April, 1887, he became a member of the staff of Lockwood, Greene & Company, the engineering firm which had designed the Washington Mills, and two years later was made first assistant to Mr. Stephen Greene, then the sole member of the firm. From that time until his death, Mr. Shedd maintained an intimate connection with that organization.

On January 1, 1901, on the incorporation of Lockwood, Greene & Company, Mr. Shedd became a director and the vice-president of the firm, and held both these positions until his death. He was a civil engineer of high standing, and had designed many large mills and hydraulic plants in various parts of the United States and Canada, having been considered one of the leading authorities in this country on hydraulic developments.

Mr. Shedd was a man of varied interests; a member of the American Society of Civil Engineers and of the American Society of Mechanical Engineers, he was also a member of St. John's Lodge, A. F. and A. M., of Boston, a Companion in the Mount Vernon Royal Arch Chapter, and a member of the Second Parish Congregational Church, of Dorchester, Mass.

Mr. Shedd was also a member of the New Hampshire Historical Society and a life member of the New England Historic Genealogical Society. He was the founder, as well as the secretary and treasurer, of the Shedd Family Association, and designed the handsome monument,— erected at Shedd's Neck, in Quincy, Mass., three weeks prior to his death, by the Shedd Association, — in honor of the first ancestor of the family in America. Having been for many years much interested in genealogical research, he had collected many valuable data regarding the Shedd descendants in America, and was making plans, when taken sick, looking toward the early publication of a genealogy of the family.

Mr. Shedd was a thorough, painstaking engineer, of retentive memory, wise judgment, and tireless industry; a modest, unobtrusive gentleman of sterling character. One of his friends says of him:

" He was a high-minded citizen and represented the highest ideals of human life; he rendered a large service to his fellowmen; he was an honor to his profession and has left behind him a name which ought to be an inspiration and help to us all for higher and better things."

During his illness, which covered the last six months of his life, Mr. Shedd suffered much, but bore his sufferings with great fortitude, and attended to many affairs up to the very last. He died at his home in Dorchester, Mass., on September 22, 1916, leaving a widow and one son.

Mr. Shedd was elected a member of the Boston Society of Civil Engineers on April 19, 1905.

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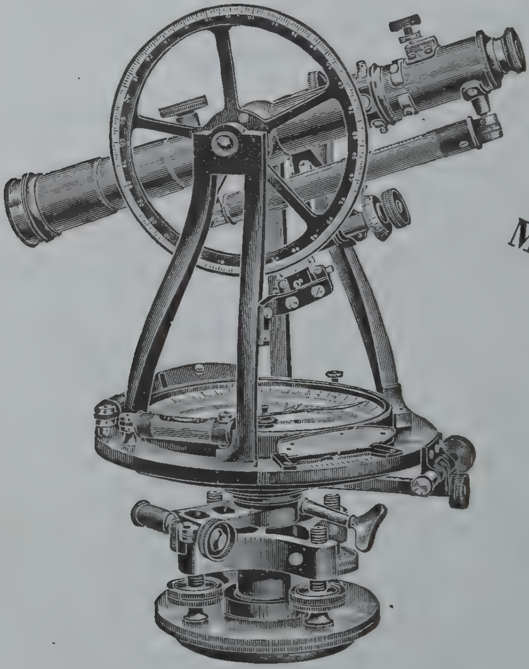

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